European white elm (*Ulmus laevis* Pall.) biomass production in high-density plantation

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Abstract

This paper provides first report for European white elm potential for biomass production. High density plantation (71,428 seedlings ha^{-1}) was established on spring 2012th near Belgrade from one-year-old seedlings, produced from seed. Weed control and irrigation was practiced only in the first growing season, without fertilization. In a three year rotation, European white elm plants in a high density plantation reach average height of 341.11 cm and average root collar diameter of 31.9 mm, with height increase of about 1 m, diameter increase of about 1 cm per year. At the end of three-year rotation total produced biomass was 90 odt ha^{-1}, or 30 odt ha^{-1} year^{-1}. Biomass production of European white elm is in range or higher compared to traditionally used species, indicating the need for further research on planting material, plant density and cultural practices.

Keywords

European white elm; Biomass production; High-density plantation; Short rotation plantations; Energy plantations

Contents

1 Introduction

Short rotation coppice (SRP) for biomass production present very important renewable energy source (Tubby and Armstrong 2002, Facioto et al. 2009). European Union has planned to increase involvement of renewable energy sources for 20% until year 2020 (Gasol et al. 2008, Redei et al. 2011). The SRC plantations for production of biomass are reported in a number of countries like Sweden (Dimitriou and Aronsson 2005, Mola-Yudego et al. 2014), Italy, Poland and Great Britain, and Germany (Dimitriou and Aronsson 2011). The most common species are poplar and willows, but risk of establishment monocultures is high and requires testing and introducing of new species (Ivetić and Vilotić 2014). Numerous researchers indicate for potential of different species and intraspecies taxa for biomass production (Spinelli 2007, Nassl O Di Nasso et al. 2010, Huber et al. 2014, Bianco et al. 2014). Due to its biological characteristics European white elm (*Ulmus laevis* Pall.) show a potential as species for biomass production. Previous studies in Serbia (Devetaković et al. 2015, Devetaković 2017) and Turkey (Cicek et al. 2011) focused on testing European white elm potential for reforestation, reported high survival and growth rate. In addition, European white elm is reported as a species with high regenerative potential (Grbić 1992, 2003) which indicate possibilities for its use in more than one rotation in a SRC management. This research tested a European white elm potential for use in a high density SRC plantations.

2 Material and method

The field trial was located near Belgrade (Serbia) at 44° 30 ’54.68’’ N, 20° 25’ 41.81’’ E, and at an altitude of 180 m. The climate is continental with expressed seasons. Average annual rainfall is 667.9 mm, while July and August common are dry and very hot after June which is the most rainfall month. During three year cycle typical year was only 2013th, while summer of 2012th was extremely dry and hot and summer of 2014th was extremely rainfall. The soil of the study site is a deep moderately fertile soil, according WRB classification named Vertisol. The pH of the soil generally varies from 6.7 to 7.2, humus content is less than 3 % and with low content of calcium. The area previous was used for agricultural production.

Experimental plantation was established on the rectangular flat field (dimensions 25 m x 40 m) in March of year 2012. Seedlings were produced in a neighboring field from seed collected in the natural European white elm population at Veliko ratno ostrvo Island near Belgrade (total of 13 open-pollinated families). Seedlings were planted in rows at a distance 0.7 m between rows and 0.2 m between seedlings in a row, which resulted with 71,428 plants ha^{-1}. Cultural practices (weeding and irrigation, without fertilization) were limited to the first growing season only.

At the end of third growing period measurements of height and root collar diameter was performed at the sample of 650 plants (13 rows X 50 randomly selected plants). Sample of 40 randomly selected plants were cut and transported in the Laboratory for testing of seed and seedlings at Faculty of Forestry in Belgrade where was measured: root collar diameter (D1), diameter on the 20 cm of height (D2), height (H1) and dry mass (m) of plants, after drying on the 68±2˚C during 48h (Ivetić, 2013). Calorific value of the samples was measured in Laboratory for coal quality testing within RB "Kolubara" in Lazarevac following standard procedure for measurements of coat calorific values.

3 Results

At the end of third growing season in plantation average height of trees was 341.11 cm and average root collar diameter was 31.9 mm. Trees of different families showed significant differences of height and root collar diameter. Differences between families was statistically significant and confirmed by ANOVA test (OneWay Anova, $p<0.05$).

After drying on air average mass of plants was 482.9 g and after standard drying in dryer average mas of plants was 425.8 g. Relationship between observed parameters (H1, D1, D20, m) are statistically significant (p<0,01), except height and dry mass (Table1).

Table 1. Relation between observed morphological parameters.

N=40	D1	D2	H	m
D1	1.00			
D2	0.64*	1.00		
H	0.53*	0.51*	1.00	
m	0.86*	0.72*	0.53	1.00

Biomass production can be observed as linear regression relative to mass as well, but the best indicator was diameter, firstly D1 and than D20 (Figure 1).

Total biomass production was 90 odt ha^{-1}, respectively 30 odt ha^{-1} year^{-1}. Calorific value of European white elm wood is 18404 KJ/kg with the hygroscopic moisture 3.2 % and ash content 0.95 %.

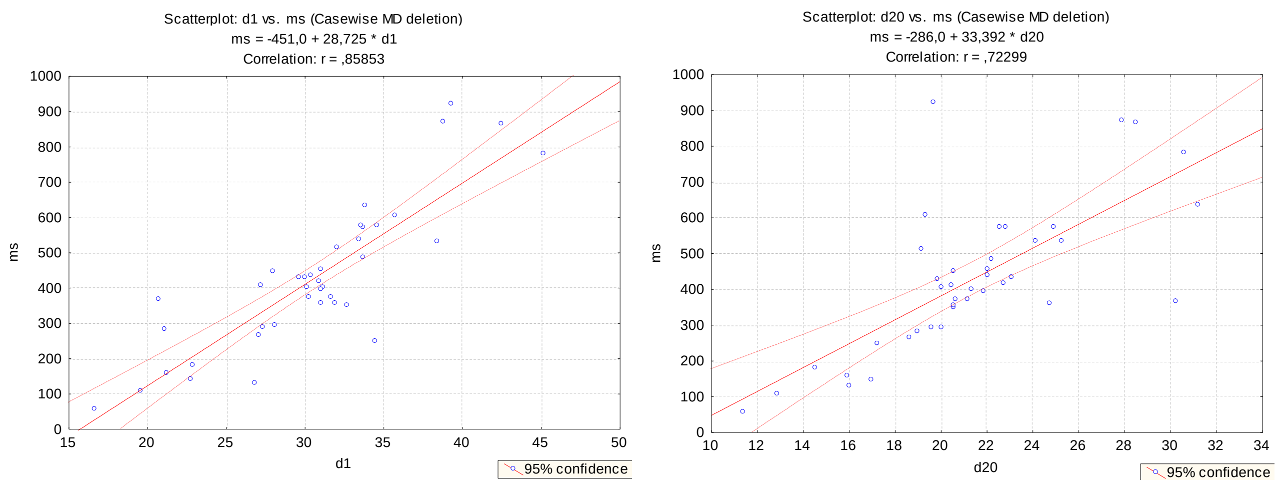

Figure 1. Correlation between dry mass and D1 (left), and r D20 (right).

4 Discussion

Average yearly increment of height and diameter (1 m and 1 cm) suggest European white elm as fast growing species. Biomass production of 30 odt ha^{-1} year^{-1} is higher than a result reported by Facciotto et al. (2009) for elms in Italian plantations during 2 years, where planting density was 10,000 and with weed control and fertilization. This research show biomass production higher than some traditionally used species, as poplars (Aylott et al. 2008, Facciotto et al. 2009), willows and black locust (Facciotto et al. 2009) during three years cycle, but in different environmental conditions and with different plant density and cultural practices. However, the calorific value of European white elm wood is in range of poplars and willows wood from plantations (Klašnja et al. 2002). In this research plant density was significantly high which probably effect on total biomass production. High density plantations of *Leucaena leucocephala* and *Eucalyptus tereticornis* showed similar yield (Singh and Toky 1995) per year during 4 year as European white elm in this research. Observed plantation was established on the soil type vertisol with modest nutritive content and without fertilization, and better results can be expected on soils with higher nutritive content or with fertilization. Different plant density can affect different yield, so future testing is needed to provide optimal planting density.

European white elm has high potential for purpose short rotation plantations. Biomass production during three year cycle is significantly higher than other tested elms and it is in range of traditionally used species for biomass production. Future research need to provide optimal planting material, plant density and cultural practices, also as testing on different soils and environmental conditions.

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